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HUMAN FACTORS IMPLICATIONS OF MICV OT II FOR INFANTRY FIGHTING VEHICLE (IFV) DEVELOPMENT

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FORT BENNING FIELD UNIT

U. S. Army
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An intensive evaluation of the human factors aspects of the Mechanized Infantry Combat Vehicle (MICV) was conducted as a part of the MICV Operational Test (OT) II. Data from this evaluation are presented and analyzed for implications for the development of the new Infantry Fighting Vehicle (IFV). The methods used to obtain the human factors data also are discussed.

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FOREWORD

The research reported here was performed by the Army Research Institute's Fort Benning Field Unit in close coordination with and in support of the U.S. Army Operational Test and Evaluation Agency (OTEA) as part of the MICV (XM723) Operational Test (OT) II conducted at Fort Benning, Ga. The study was also a part of an ongoing ARI program of research on human factors and training aspects of Army infantry systems, with emphases on system development and system evaluation. The test materials were developed in response to a request from OTEA for ARI assistance in the human factors portion of the MICV OT II. The research design and the data collection and analysis plans for this segment were developed and carried out largely by ARI with the assistance of CPT Albert J. Truesdale, OTEA in coordination with Dr. David Chananie, OTEA. The project demonstrated the usefulness and value of collaborative effort between ARI and OTEA. This report presents the results of questionnaires, interviews, and field observations administered to the mechanized infantry participants in the OT II. A major purpose of this paper is to point out the design and human operator implications of the OT II data for further development of the Infantry Fighting Vehicle.

The project was conducted as part of Army Project 2Q763731A773, FY 76 Work Program, and Project 2Q763743A773, FY 77. It was directly responsive to the requirements of USAOTEA, the Army Intelligence Center (USAIC), and the Army Training and Doctrine Command (TRADOC).

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HUMAN FACTORS IMPLICATIONS OF MICV OT II FOR INFANTRY FIGHTING VEHICLE (IFV) DEVELOPMENT

BRIEF

Requirement:

To obtain comprehensive human factors data from user personnel to assess the adequacy of the Mechanized Infantry Combat Vehicle (MICV), XM723, for each crew position in comparison to the M113A1.

Procedure:

Eighty-three mechanized infantry company personnel who were test subjects in the MICV OT II provided data through detailed questionnaires, interviews, and field observations. These human-factors-oriented instruments were designed to obtain comprehensive information from "user experts" to assist designers and decisionmakers. Test instruments covering vehicle and equipment problems and their possible solutions were used throughout the OT II. Because the data reported here were gathered primarily at the end of the program, they represent a summary of several months' exposure to both infantry vehicles.

Findings:

The MICV, XM723, was judged in speed, maneuverability, fire power, and armor protection to be more desirable for combat use than the M113A1. However, the MICV was also rated deficient in several design-related areas. Crowded conditions delayed entrance and exit, particularly for the track commander (TC), and degraded necessary performances (for example, operating firing port weapons). Visibility, especially for the TC, was seriously limited, causing major command and control problems, including fire control and communication. The design of the main gunner's station caused several operator problems based on complexity, weight, and other weapon characteristics. Port weapon gunners also had difficulties such as firing capability and bulky weapons rack.

Data are presented for each duty position in both the MICV and the M113A1. Problems are identified and suggestions offered where appropriate.

Utilization of Findings:

These results should be carefully studied for possible improvements in the future evolution of IFV. There is a tendency for data from users to have altogether too little impact on final equipment design. The soldiers who participated in OT II were a valuable resource for expert feedback on MICV problems, solutions, and modifications. Listening to their advice could greatly improve the final vehicle.

HUMAN FACTORS IMPLICATIONS OF MICV OT II FOR INFANTRY FIGHTING VEHICLE (IFV) DEVELOPMENT

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INTRODUCTION

From August 1976 through March 1977, the Mechanized Infantry Combat Vehicle (MICV), XM723, underwent its Operational Test II (OT II) at Fort Benning, Ga. The MICV OT II was a comprehensive test of prototype MICV's operated in combined arms exercises by members of a combat-ready mechanized infantry company. The various field and live-fire tests were designed to compare the MICV with the standard Armored Personnel Carrier (M113A1), evaluating vehicle and squad performances.

The Army Research Institute Field Unit at Fort Benning agreed to assist the U.S. Army Operational Test and Evaluation Agency (OTEA) in obtaining comprehensive user data concerning human factors aspects of the MICV. Through daily exposure to both vehicles under test conditions, the mechanized infantry company personnel became experts whose problem identifications and design recommendations are worthy of special note and should be incorporated as major design inputs to the MICV--TBAT II (IFV).[1]

To support this product improvement process, this report will

1. Describe ARI's assistance to OTEA in obtaining evaluation and design relevant data from the users,
2. Indicate the research methods for obtaining the data,
3. Summarize the most important findings, and
4. Present the implications that the MICV OT II offers for the development of a successor vehicle.

METHOD

The overall MICV OT II program included many different measurements including mechanical reliability, incidence of component failures, live-fire performance, and competitive results of simulated combat

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[1]The projected improvement of the MICV was first designated TBAT-II (TOW, Bushmaster, Armored Turret--Two Man). It recently has been called the IFV (Infantry Fighting Vehicle).

against threat forces during exercises. These data are fully covered in the OTEA report of the OT II.[2] The present report will focus only on human factors and other aspects of "user expert" data.

Data Comparisons

The operational test provided opportunity to make two useful comparisons.

MICV versus M113A1. Each platoon in the test participated in offensive, overwatch, and defensive exercises along with main battle tanks. Since each crew performed equivalent trials in both vehicles, the participants could answer most research questions in relation to both vehicles. The M113A1 became a baseline against which to judge the adequacy of the MICV, although large design differences precluded some basic comparisons (for example, the MICV can "fight" while buttoned up, but the M113A1 cannot).

Duty Position. Participants typically were assigned consistent duty positions in both vehicles throughout the OT II. Therefore, it was possible to obtain comparable data about both vehicles for each duty position. The positions separately studied were track commander (TC), driver, main gunner, firing port weapon gunners (MICV only), and other squad members (M113A1).

Subjects

The 83 MICV OT II participants whose data are reported here were members of B Company, 1st Battalion, 58th Infantry (Mechanized), Fort Benning, Ga. The men operated in their usual platoon and squad compositions. Usable comparative data were gathered from 12 TCs, 12 main gunners, 14 drivers, and 45 firing port weapons (FPW) gunners who had no specific duties while riding in the M113A1.

Measurements

Questionnaires, field observations, and interviews comprise the data base of this report.

Questionnaires. Several questionnaires were designed to probe the depth of crew members' experiences with the vehicles. The subjects covered by the questionnaires included general human factors, adequacy

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[2] Mechanized Infantry Combat Vehicle (MICV), XM 723, System Operational Test II. Final Test Report, U.S. Army Operational Test and Evaluation Agency, June 1977.

of design, identification of features needing redesign, general and position-specific problems relating to vehicle and squad operation, and ratings of overall vehicle adequacy.

Earlier forms of questionnaires were given at various times after individual field exercises. Questionnaire item changes were made throughout the OT II test period based on the early responses and from field observation. Comprehensive final forms were prepared shortly before termination of all field testing. They thoroughly examined participants' experiences and problems in functioning as squad members and in using the vehicles and equipment. These questionnaires were administered to all users after the final exercises were completed and used as the primary data for this analysis and report.

All questionnaires used numerically scaled answer formats where possible. Earlier forms had many openended questions to broadly determine experiences. The final forms contained numerically scaled items covering every good and bad feature that surfaced during the test.

Brief comments about each questionnaire follow; Appendix A presents more complete information.

1. General Human Factors. This questionnaire, for very broad human factors coverage, consisted of 54 general items applicable to all squad members and both vehicles, followed by from 8 to 55 additional items specific to and depending on the respondent's duty position. Each item was a statement of a possible problem. Examples are

- Crowding or cramped space while in the vehicle,
- Discomfort while riding at high speeds,
- Objects in the vehicle that were safety hazards,
- Difficulty leaving the vehicle from a seat, and
- Obstructions blocking the view from the hatch.

The statement was rated by indicating how much of a problem it had been throughout the OT II (0 = no problem, 1 = a minor problem, 2 = a moderate problem, and 3 = a serious problem). The questionnaire was given twice, the MICV and the M113A1. The forms for drivers and the forms for TCs were identical for both vehicles. Main gunner's forms for the two vehicles were different due to major system design and function differences. Because the MICV uses six crew members as firing port weapon (FPW) gunners and the M113A1 has no such duty position, questionnaires designed for these squad members reflected these differences.

2. Quality of Comparative Design. This instrument consisted of 44 categories for comparing the design adequacy of the MICV and the M113A1. Examples are

- Maneuverability,
- Ease of weapons maintenance,
- Field of view for track commander,
- Performance of vehicle in heavy rain, and
- Ability to keep up with main battle tanks.

The men rated the design of each vehicle on each category (0 = not good, 1 = somewhat good, 2 = good, and 3 = very good). The same form of this test was used for every crew position.

3. Potential Redesign Elements. This questionnaire consisted of 40 MICV features, such as

- Hatches,
- Personnel heater,
- Driver's controls,
- Periscopes, and
- The seat.

Respondents rated each item (only for the MICV) in terms of redesign (0 = no redesign needed; 1 = redesign desirable, but might manage without it; and 2 = redesign absolutely necessary, dangerous or serious problem if not modified). All persons were given the same questionnaire. Each time an item was rated 2 (redesign absolutely necessary) the squad member was asked to state the difficulty and possible solution.

4. Miscellaneous Measurements. Other questions were asked for comparative overall ratings of the two vehicles, such as which one the crew member preferred for combat, or were asked about various weather and field conditions tested or not tested throughout OT II.

Field Observations. Frequent observations were made of field exercises to learn conditions and circumstances of the OT II, to see the vehicle capabilities and deficiencies, and to interact with test participants and staff. Many valuable questionnaire revisions resulted from these field experiences. Increased interest in and cooperation with the human factors portion of the OT II program also resulted.

Interviews. Group interviews were conducted with approximately 71% of the track commanders, main gunners, and drivers on completion of all field testing. The prime purposes were to (a) obtain a better understanding of questionnaire answers, (b) find out the main MICV problems detected and the proposed solutions, and (c) make certain no important human factors had been overlooked.

RESULTS

A summary of key survey findings are presented here; detailed findings for each questionnaire appear in Appendix B.

Vehicle Preference

An overview question asked, "If you had to take either the MICV or the M113A1 into combat today, which vehicle would you prefer to use?" Table 1 gives the preferences by squad position. More than 95% of the participants preferred the MICV. Three persons had no preference and only one preferred the M113A1. The overall mean rating of 1.81 fell between "moderately" and "greatly prefer MICV." There were no significant differences among vehicle crew positions in extent of preference for the MICV.

A second question examined perceived value of the MICV. It arbitrarily assigned 100 points to the M113A1 and asked crew members to compare the two vehicles by giving more or fewer points to the MICV to show how much they felt it was worth. These results are also shown in Table 1. All group median scores were higher than 100 points. In fact, the MICV was rated 63 to 90% better than the M113A1 across crew positions.

These findings were substantiated in interviews, where the strong preference for MICV's for combat use was most often attributed to superior speed, maneuverability, fire power, and armor protection. These and related reasons were also documented in the "adequacy of design" questionnaire, sections of which are shown in Table 2. The superiority of the MICV's suspension system and overall comfort were also clearly evident.

In spite of these highly favorable ratings, squad members also detailed several potentially serious MICV problem areas that are discussed in following sections.

Table 1

Number of Men Expressing Vehicle Preference for Combat and Point Worth of the MICV Compared to 100 Points for the M113A1

Answer and scale value	TC	Main gunner	Driver	FPW/ other	Percentage of total
Vehicle preference					
Greatly prefer MICV (1)	5	6	9	24	53
Moderately prefer MICV (2)	3	1	4	8	19
Slightly prefer MICV (3)	4	5	1	9	23
Don't have preference (4)	0	0	0	3	4
Slightly prefer M113A1 (5)	0	0	0	1	1
Moderately prefer M113A1 (6)	0	0	0	0	0
Greatly prefer M113A1 (7)	0	0	0	0	0
Mean	1.92	1.92	1.43	1.87	100
MICV rated worth by position					
Mean points given MICV (M113A1 baseline = 100)	171	163	190	175	--

Table 2

Comparison of the MICV Versus the M113A1 in Adequacy of Design

Item	Group mean ratings[a]	
	MICV	M113A1[b]
Speed of vehicle	2.80	1.16
Maneuverability	2.55	1.69
Firepower of the main weapon(s)	2.58	1.40
Ability to fire main weapon(s) accurately on the move	2.29	.88
Ability of the squad to fight from inside	2.22	.51
Protection of the vehicle armor	2.14	1.14
Protection for the main gunner	2.30	.48
Ability to keep up with main battle tanks	2.65	.71
Ability to go where main battle tanks can go	2.54	1.11
Ability to see out while buttoned up	1.92	.64
Vehicle suspension system	2.48	1.06
Comfort of ride	2.37	.72

[a]Group means of ratings where 0 = not good, 1 = somewhat good, 2 = good, and 3 = very good.

[b]All differences shown between ratings for MICV and for M113A1 were statistically significant ($p < .001$).

Vehicle Size and Crowdedness

Table 3 summarizes vehicle size and space problems. The M113A1 (1.44) and the MICV (1.45) are both viewed as moderately crowded and cramped. Within the MICV, leg room (1.43) appears more problematic than head room (.85), but both are rated as significantly more serious by TC's and FPW gunners than for other positions. Although both vehicles were rated about the same on the space criteria, there were several areas where the MICV was seen as significantly worse as shown in Table 3. It is harder to enter and leave the MICV, particularly from the TC's position. Prime problems are other seats and the weapons rack that block the way and objects and protrusions that snag clothing and web gear or are safety hazards. There is also little room in the MICV to care for injured persons.

Table 3

Size and Crowdedness Problems as a Function of Vehicle Type

Human factors problem	Group mean rating[a]	
	M113A1	MICV
Difficulty getting over or by other seats	1.47	1.62[b]
Difficulty entering the vehicle to get to a seat	.79	1.20
Difficulty getting out of the vehicle from a seat	.93	1.27
Clothing and web gear snagging when entering or leaving vehicle	1.26	1.76
Protruding objects that are safety hazards	.88	1.21
Weapons rack location	.73	1.35
Ability to care for injured persons in the vehicle	1.31	1.59

[a]Group means of ratings where 0 = no problem, 1 = a minor problem, 2 = a moderate problem, and 3 = a serious problem.

[b]All mean differences are statistically significant ($p < .05$ or better).

The most frequent suggestions were (a) to provide springloaded seats that would not protrude when unused, (b) to eliminate or greatly reduce the size of the weapons rack, and (c) to recess or relocate the worst snags and protrusions, particularly in passage areas.

Visibility

The most obvious and serious visibility problem with the XM723 MICV is the obstructed view from the track commander's hatch. Although half the TC's said there were no TC visibility problems in the M113A1, 10 of 12 indicated "moderate" or "serious" problems seeing from the MICV. Items dealing with visibility are detailed in Table 4.

Visibility from the main gunner's station was considered generally adequate for both vehicles but there were fewer problems for the MICV main gunner when "buttoned up" either at night or in bad weather.

Mud coating the periscopes was rated as a significantly worse problem for the MICV, particularly for the driver and TC. The same trend is evident for other periscope problems such as vibration, glare, and fogging. Drivers and TC's also reported several instances of periscope covers falling or being knocked down by shell casings. Although rain leaking around MICV periscopes may not have hampered visibility, it generated considerable crew member discomfort and annoyance.

Overall, visibility for MICV main gunners and FPW gunners was apparently satisfactory, although mud coating was a moderate problem for the latter. The design for driver and TC visibility was no better in the MICV than in the M113A1 and in some cases was worse.

MICV recommendations centered around relocating the TC into the turret and correcting mud flap deficiencies, periscope rain leaks, vibration, and falling periscope covers.

Track Commander's Station

In addition to the TC's entrance/exit and visibility problems, several other MICV design relevant findings relating to command and control emerged. The TC in the MICV had difficulty communicating with and controlling actions of other crew members as indicated by items in Table 5. He had no difficulty coordinating with the driver while in the vehicle. However, lack of a TC-to-vehicle radio and the potential for the turret to block the driver's view of the TC impeded control when dismounting. The TC's poor ability to control vehicle weapons fire stemmed from his own limited external vision and also from his inability to signal most gunner positions using sight, sound, or touch. Presuming that the TC will be located in the turret in the next version of the MICV (the TBAT-II IFV), some of the TC's problems found in the

Table 4

Group Mean Ratings of Visibility from the M113A1 and MICV

Visibility conditions	TC		Main gunner		Driver		FPW gunner	
	MICV	M113	MICV	M113	MICV	M113	MICV	M113
Vision in daylight, hatch open	.83	.25	.08	.00	.14	.00	N/A	N/A
Vision at night, hatch open	.92	.42	.33	.33	.29	.07	N/A	N/A
Vision in bad weather, hatch open	1.17	1.00	.75	.83	1.00	1.62	N/A	N/A
Vision in daylight, buttoned up	1.67	N/A	.58	.50	.86	.93	.77	N/A
Vision at night, buttoned up	2.17	N/A	1.25	2.33	1.00	1.57	1.25	N/A
Vision in bad weather, buttoned up	2.08	N/A	1.17	1.92	1.85	1.77	1.34	N/A
Mud, etc. on periscopes	1.83	1.17	1.33	1.50	2.07	1.00	1.50	N/A
Fogging of periscopes	1.33	1.08	1.50	1.50	1.50	.86	1.07	N/A
Vibrating periscopes	1.08	.75	.58	1.50	1.07	.57	.60	N/A
Glare on periscopes	1.25	.92	1.00	1.08	1.14	.86	.67	N/A
Periscope covers falling or knocked down	1.40	.50	N/A	N/A	1.36	.14	N/A	N/A

Note. 0 = no problem, 1 = a minor problem, 2 = a moderate problem, and 3 = a serious problem.

N/A indicates no data because this crew member had no hatch or couldn't see out under this condition.

MICV OT II will be corrected.[3] Effective communication with crew members is probably an exception. Evidence from the OT II indicates that communication equipment, its locations, and standard operating procedures (SOP's) for its use need careful study if the MICV system is to function maximally.

Table 5

Ratings of Potential Problems for Track Commanders

Potential problem	Vehicle	
	MICV	M113A1
Command and Control-Vehicle		
Ability to control driver when in vehicle	.58	.92
Ability to control driver when dismounted	1.83	1.58
Command and Control-Weapons		
Ability to control firing of main weapons	1.50	1.00
Ability to guide main gunner using LED panel	.90	N/A
Ability to guide firing of FPW positions	1.70	N/A
Difficulty with target detection from TC's position	1.83	.92
Ability to control vehicle firing when dismounted	2.17	1.83
Command and Control-Squad		
Difficulty commanding squad because of dismount delays	1.45	.91
Difficulty commanding squad because of having to enter vehicle first on left side	1.50	.92
Intercom/Radio		
Adequacy of radio equipment	1.17	1.17
Adequacy of intercom equipment	1.33	1.50
Malfunctions of radio/intercom system	1.50	1.67
Broken headsets	2.18	1.00
Headset/helmet difficulties during dismount	2.00	1.17

Note. 0 = no problem, 1 = a minor problem, 2 = a moderate problem, and 3 = a serious problem.

[3]Because of this redesign, most findings relating to the TC compartment area will be omitted. However, TC questionnaire answers are given in Appendix B.

Interviews with track commanders indicated control of the vehicle while dismounted was a serious communication problem. The current lack of a suitable short range radio link for that purpose was seen as a serious system flaw. Some TC's also suggested exploring the use of a loudspeaker to provide better control of the squad while mounted. They strongly encouraged the use of metal checklist operator plates bolted near duty stations (for example, driver, main gun) to reduce error and omission. They also felt handicapped by the lack of night vision equipment to aid them in controlling weapons firing.

Driver's Station

Overall, of all squad members the drivers tended to be the most favorable toward the MICV (see Table 1). The improved power, maneuverability (notably ease of steering), and ride stabilization led drivers to rate their tasks in the MICV generally more favorably than those performed in the M113A1. Nevertheless, they also noted some MICV problems as shown in Table 6.

Table 6

Ratings of Potential Problems for Drivers

Potential Problem	Vehicle	
	MICV	M113A1
Difficulty steering vehicle	.29	1.21
Difficulty operating accelerator	.43	.29
Difficulty operating brakes	.43	1.21
Difficulty reading any visual display	1.21	.43
Difficulty seeing all instruments in some driving positions	1.79	.93
Adequacy of mud flaps	1.58	.92
Adequacy of night vision equipment	.64	1.29

Note. 0 = no problem, 1 = a minor problem, 2 = a moderate problem, and 3 = a serious problem.

Questionnaire data did not reveal MICV brake problems, but drivers in the interview said they found the brake awkward because they had to push it straight down (rather than forward and down). The drivers said this factor, combined with excessive play, led to many abrupt stops. As a related matter, the MICV ramp control handle was positioned so

that drivers often had to operate it by foot; they said it was hard to lower the ramp quickly when stopping suddenly.

The MICV drivers couldn't read displays easily when in open-hatch modes. They strongly recommended moving the main display panel to the left side of the hatch where they felt it would always be visible.

The MICV mud flaps were severely criticized. Generally, the flaps were easily torn and did not adequately deflect debris from hatches and periscopes. Because of the low and forward position of the driver's hatch, drivers were considerably bothered by debris, especially in bad weather. They reported that during cross country travel, weeds and dust blew in their faces, funneled by the gap between the hull and trim vane.

Several miscellaneous MICV problems were identified during interviews. Items sliding forward on the floorboards could lodge under the accelerator, causing it to jam. In maintenance activity, drivers all reported difficulty with the engine oil check position and said it was hard to reposition and bolt the engine access panel. When one vehicle was operating, they also had trouble reaching and placing the hatch pin to shift, for example, into clam shell position. Expended shell casings, in addition to hitting periscopes, sometimes deflected into the hatch, causing minor injuries. Finally, drivers reported some confusion about information received by intercom. The TC's voice could not always be easily identified.

Main Gunner's Station

The MICV main gunner operates a 20mm cannon and a coaxially mounted 7.62mm machine gun from a powered, protected turret. In contrast, the M113A1 gunner manually operates a 50 caliber machine gun exposed in an open hatch. These different design and fire power features precluded some data comparisons. The "adequacy of design" questionnaire, however, revealed several important positive and negative MICV implications, as shown in Table 7.

The gunners rated the MICV clearly superior in comfort of ride, firepower, ability to fire weapons accurately on the move, and in the protection afforded to them. However, in reliability and ease of maintaining the weapon system the M113A1 was rated higher. Regarding "things needing redesign" problems with the MICV weapons system were also noted (see Table 8). Gunners felt redesign of both the machine gun and the 20mm cannon was desirable. They also indicated need for turret redesign to deal with tight space, rain leaks, lack of heating, and injured gunner aid.

Table 7

Main Gunners' Ratings of Adequacy of Design

Item	MICV	M113A1
Comfort of ride	2.42	.67
Fire power of the main weapon(s)	2.50	1.33
Ability to fire main weapon(s) accurately on the move	2.17	.92
Protection for the main gunner	2.08	.50
Reliability of weapons system	1.42	2.17
Ease of weapons maintenance	1.50	2.33

Note. 0 = not good, 1 = somewhat good, 2 = good, and 3 = very good.

Table 8

Main Gunners' Ratings of Items Needing Redesign

Problem	MICV rating
Space in vehicle to accommodate large men	1.08
Coax machine gun	1.00
20mm cannon	1.00
Dual feed system	1.00
Night sight	.92
Personnel heater	.83
Places where rain leaks occur	1.17
Ability to aid an injured main gunner	1.25

Note. 0 = no redesign needed, 1 = redesign desirable, but might manage without it; and 2 = redesign absolutely necessary, danger or serious problem if not modified.

Responses to the human factors questionnaire items, shown in Table 9, give more detail on the foregoing and other problems. The data reveal that the turret was crowded and was difficult to enter and exit. Snags caught clothing and there was no space to store personal weapons. Although most crew members found the ride comfortable, gunners still

indicated they were thrown around in the turret when on the move. The complexity of the weapon systems led to some decisionmaking confusion and required multiple, nearly simultaneous tasks. However, these gunner activities were not tested under simulated combat, where confusion and stress could seriously degrade performance, especially for inexperienced gunners. Several other problems with the turret weapons also were revealed by questionnaire items, particularly complexity, weight, ammunition feed, load times, and general reliability.

Table 9

Human Factors Questionnaire Ratings of Main Gunners

Item	MICV	M113A1
Discomfort while riding at slow speeds	.25	1.08
Discomfort while riding at high speeds	.67	1.58
Being bounced around while under way	.92	2.50
Difficulty entering the vehicle to get to seat	.92	.58
Clothing and web gear snagging when entering or leaving vehicle	1.75	1.08
Ability to get to squad weapons when required	1.25	.58
Too little space in the turret	1.50	N/A
Amount of storage space in the turret	1.50	N/A
Confusion due to the number of tasks needed (e.g., checking switch positions) to get ready to engage a target	1.09	.18
Confusion because of the number of decisions to be made (e.g., which weapon to use) when getting ready to engage a target	.83	.33
Ability to remain oriented as to vehicle direction	1.17	.58
20mm weapon has too many parts	1.17	N/A
Difficulty loading the guns	1.25	N/A
Difficulty correctly installing the dual feeder	1.33	N/A
20mm weapon dual feeder too heavy	1.83	N/A
Jamming of the dual feeder	1.75	N/A
Difficulty with image quality of the night sighting equipment	1.25	N/A

Note. 0 = no problem, 1 = a minor problem, 2 = a moderate problem, and 3 = a serious problem.

Interviews with gunners indicated the need to improve both main weapons considerably. Keeping weapons clean, loaded, and operational were viewed as major problems. Larger and more easily managed ammunition boxes were suggested.

Turret location using the LED panel was no problem when the panels were synchronized in the various stations--but they often were not. It was suggested the panel would be easier to use if it had a continuous pointer and it were oriented in the general plane of turret movement (for example, 12:00 facing to the front rather than up).

Gunners were concerned about automatic gun raising when over a hatch and weapons cutoff when aimed low. Although linked to safety, these concerns also affect combat capability and were considered serious detriments.

Firing Port Weapon Gunners' Stations

Other crew members cannot fight from inside the M113A1 unless the cargo hatch is open. The MICV was designed to allow six FPW gunners to fire while "buttoned up" from ball-in-socket ports, by looking through viewing blocks. Although FPW weapons data are therefore not comparable between vehicles, a few comparisons are possible. Crowding, the weapons rack problem, and lack of leg room, were mentioned earlier. Other data are given in Table 10. Being able to see out of the vehicle was advantageous for MICV occupants who appeared to be somewhat less likely to be motion sick and were more able to keep track of where they were. They were also more able to hear commands due to lower noise inside the MICV but showed some problems coordinating with the TC.

Several other FPW gunner problems require attention. It was not possible to sight directly because the FPW viewing port was several inches above the gun barrel. It was necessary to adjust the fire onto the target using tracers, initial aiming either high or low was a problem. Gunners couldn't adjust the height of their seats; for some this contributed to difficulty in sighting and firing. Because of obstructions and crowding, gunners also had insufficient room to swivel their weapons to fully cover the viewed area. There was no place for extra ammunition clips. Particularly for large men, the overall crowding made operation difficult. Since the vehicles carried only a partial squad during most of the exercises, maximum capacity was rarely tested for any appreciable duration. The results of the OT II probably underestimate the severity of the crowding problem for firing port weapon gunners.

Table 10

FPW Gunner Ratings of Human Factors Questionnaire Items

Item	MICV	M113A1
Confusion about location because of limited ability to see outside while "buttoned up"	.98	1.36
Feeling motion sick when buttoned up	.68	1.09
Not enough air when vehicle was buttoned up	.68	1.14
Ability to hear commands	.89	1.39
Lack of ability to adjust seat height	1.55	--
Ability to coordinate with squad leader while in the vehicle	1.11	--
Ability to see hand signals	1.23	1.07
Ability to aim firing port weapon without the use of tracers	1.48	--
Room to move around as needed during the firing of your weapon	1.25	--
Ability to swivel weapon to cover entire viewing angle	1.34	--
Difficulty avoiding shooting too low	1.02	--
Difficulty avoiding shooting too high	1.16	--

Note. 0 = no problem, 1 = a minor problem, 2 = a moderate problem, and 3 = a serious problem.

IMPLICATIONS FOR THE IFV

This report identifies problems and suggests some solutions as a result of the MICV OT II. Nearly all findings have direct implications for further development of the IFV.

Although the XM723 MICV was favorably recognized for its speed, maneuverability, fire power, armor protection, and combined arms compatibility, several human operator deficiencies were identified during the MICV OT II. The deficiencies affected both individual crew-member stations and squad capability. Some are serious enough to have probable adverse effects on mission performance and therefore must be corrected before the detailed IFV design is frozen.

Crowding

Crowding in any fighting vehicle has to be expected and tolerated. However, the constricted space and obstructions in the current MICV

directly affect the squad's ability to perform its routine mission assignments. Delayed entrance and exit, obstructions to FPW firing, difficulty in getting to and treating the wounded, and restricted loading options need attention.

Visibility

Visibility from the XM723 is seriously deficient. Although moving the TC to the turret will correct part of the problem, the turret causes a large blind spot for the driver that remains a problem, particularly when the squad is dismounted.

Command and Control

Command and control difficulties existed during the XM723 exercises. The movement of the TC from the squad compartment to the turret will reduce some problems and possibly increase others. These functions will require careful analysis and correction.

The TC's ability to control squad member activity while inside the vehicle (particularly regarding a weapon firing) and to control the vehicle when the squad is dismounted are areas of particular relevance to the IFV program.

Communication

Communication is implied in the command and control problems. Design of intercom and radio equipment and detailed, well-designed SOP's for their use appear critical to successful IFV employment.

Human Engineering

Human engineering of each crew station in the SM723 was incomplete and in some cases seriously deficient. Specific problems and corrective suggestions have been given earlier in this paper. Others appear in the OTEA MICV OT II report. User and test personnel have made many important design suggestions that should not be overlooked (for example, spring-loaded crew seats to ease entrance and exit of vehicle).

Simplification

Simplification of the overall vehicle system should be attempted to reduce required crew expertise and training. One example is the weapon system of the turret. Design goals should include simplicity

of mechanisms, reliability of equipment, and ease of operation and maintenance. A way should be developed to use the M16A1 and/or M60 as firing port weapons to eliminate duplication of weapons brought aboard. Also, some redesigning to permit direct sighting from FPW positions would greatly improve accuracy and ease training needs.

Systems Assessment

Total systems assessment of the vehicle, its expected missions, and the crew that would typically man it, is critical. An important resource in this process should be the insights of the crew members. Evaluations and suggestions of the expert users in the MICV OT II form the body of this report. These men could and should continue to aid in TBAT II IFV development.

APPENDIX A

DETAILS OF TEST PLAN, QUESTIONNAIRES AND INTERVIEWS

A. OBJECTIVES OF THE TEST BATTERY

1. To identify any human factors problem that would adversely affect the ability of any mechanized vehicle crew member to perform his individual or interactive duties (e.g., within crew, among vehicles).

2. To identify any environmental effects (e.g., noise, lighting, vibration, fumes) caused or inadequately dealt with by the mechanized vehicle that might be expected significantly to degrade human performances.

3. To identify any safety hazards caused by the mechanized vehicle or any of its associated quipment.

4. To examine all tasks required by the operation of the mechanized vehicle generally, and all crew stations specifically, to determine whether the vehicle or its equipment present any human factors problems (e.g., operator controls, vision obstructions) that would degrade total-vehicle performance.

5. To examine the mechanized vehicle as a part of a broader system and determine whether there are any other human factors problems that degrade its ability to perform in combined arms operation.

6. Based upon all of the above, to transmit useful human factors suggestions gathered from OT II participants and to make recommendations about any designs, situations, or defects that appear to require further consideration.

B. CRITERIA AND ISSUES FOR TEST

1. The principal emphasis in the project was to determine the suitability of the MICV to perform the types of activities for which it was designed. Required characteristics include: the ability to support effective infantry-squad fighting from within the vehicle, the ability to transport the squad to an objective properly equipped and in fighting condition, and the ability to participate as an effective part of a combined arms operation.

2. The human factors data collection effort mirrored these emphases and was designed to extend previous MICV study efforts, including examinations of all human-factors-related corrections made to date of defects noted earlier.

3. Part of the expansion was to evaluate those human factors considerations stemming from the combined arms MICV operations occurring for the first time in the OT II.

4. A major criterion of evaluation was comparison of the MICV with the M113A1.

C. METHOD

1. This subtest was coordinated and conducted with other MICV OT II testing activities.

2. The data gathered under this sub-plan came from surveys and interviews placed throughout the OT II test period.

3. Much of the human factors evaluation was accomplished using a general human factors questionnaire. This overview instrument was followed by interviews to obtain detailed or expanded information, recommendations, etc. Additional human factors questions were contained in other data collection instruments.

D. DATA REQUIRED

To accomplish the above purposes, human factors and behavioral data were collected from several different MICV OT II participants having different bases of information, responsibilities, activities and points of view. Company and platoon leaders, track commander/squad leaders, gunners, drivers, firing port weapon gunners, other squad members, and members of the MICV OT II project staff were involved.

1. Pilot tests were conducted to determine the suitability of human factors instruments already developed and to aid in required test-instrument modifications and/or additions.

2. Questionnaires

1. General Human Factors Questionnaire (Human Factors Forms 61-66, Inclosure 1 of Appendix B). The purpose of the General Human Factors Questionnaire was to find out as much as possible about problems (and good features) in human use of the MICV and M113A1 mechanized vehicles. The questionnaire had many items to be answered as it covered areas of design and function which might need further work and correction.

There were separate forms of this questionnaire for the MICV and M113A1 and specific forms for various jobs the vehicles required (e.g., driver TC, main gunner). Specific information was gathered to find out what improvements are required to aid the various vehicle occupants.

The questionnaire was used to obtain general information and was followed later with interviews to obtain specific information in each area which appeared to be problematic.

The questionnaire began with several general questions, common to all respondents, followed by questions more specific to different squad member positions and/or to type of vehicle. These requirements led to the nine different test forms shown below:

Forms of The General Human Factors Questionnaire

Squad Member Position	Vehicle	
	MICV	M113A1
Driver	Form 61 (MICV)	Form 61 (M113A1)
Main Gunner	Form 62	Form 63
Track Commander	Form 64 (MICV)	Form 64 (M113A1)
Firing Port Weapon Gunner	Form 65	-
Other Squad Members	Form 66 (MICV)	Form 66 (M113A1)

Details of these questionnaire forms, including copies of the various Forms and instructions to the squad members are given in Inclosure 1 of Appendix B.

Each squad member filled out the questionnaires during the pilot data collection period and again after final exercises. Because squads used both the MICV and M113A1 vehicles during their OT II participation, each person filled out both the MICV and the M113A1 form appropriate for his position.

This data collection plan permitted several important comparisons to be made as follows:

(a) Extent to which each questionnaire item was perceived as a problem.
(b) MICV vs. M113A1 differences and similarities.
(c) Differences in perceived problems as a function of duty position in vehicle, and;
(d) When examined in conjunction with interviews:
(1) Details of the problems revealed by the questionnaire.
(2) What procedural or equipment changes need to be made to deal with the problem.

b. Quality of Comparative Design Questionnaire (Inclosure 2 of Appendix B). The purpose of this questionnaire was to evaluate both the MICV and the M113A1 on various features that would be considered desirable for an infantry fighting vehicle to possess. It was a means for obtaining information comparing the adequacy of design of the two vehicles. While the General Human Factors Questionnaire centered mostly on possible problems, the Quality of Comparative Design Questionnaire focused on positive design features and allowed the respondent to indicate how well they had been achieved.

The same form of this questionnaire was given to all test participants at the conclusion of field testing when they had completed extended experience operating both vehicles. The questionnaire was completed by assigning a rating to each vehicle for every item of the questionnaire.

A copy of the questionnaire is contained in Appendix B as Inclosure 2. It lists the average ratings given to the two vehicles by the test subjects.

c. Things Possibly Needing Redesign (Inclosure 3 of Appendix B). The purpose of this form was to assess the perceived requirement for redesign of many possible sub-systems of or items in the MICV. The same form was given to each participant in the OT II. He rated the MICV for each item and was further asked to provide specific problem information and projected solutions to any area he rated as "Redesign absolutely necessary".

A copy of the test instrument is contained in Appendix B as Inclosure 3. For each item the average MICV rating is given for each duty position separately.

Appendix B

DATA SUMMARIES

1. GENERAL HUMAN FACTORS QUESTIONNAIRE, INCLOSURE 1

Two instructions-to-subjects forms were used, one to refer to MICV, the other to M113A1 as shown below:

M1CV

One important part of this operational test is to find out directly from each of you what your experiences have been while riding and doing your job in the MICV. We are going to ask about many different things, like conditions inside, possible safety hazards, difficulty in using the equipment, and problems in doing your job. In answering this questionnaire please give information only about your own personal experiences with the MICV.

For each statement in the questionnaire please select one of the four answers listed below. Your answer will tell us how much of a problem that item has been throughout the test while you have been riding and doing your job in the MICV. The answer choices are:

0 no problem
1 a minor problem
2 a moderate problem
3 a serious problem

In deciding your answer, please consider both how often and how much the item has been a problem for you. Please indicate your answer choice (0, 1, 2, or 3) in the space in front of the item.

Additionally, some statements may ask for a short response. Please write these comments on the lines provided.

M113A1

One important part of this operational test is to find out directly from each of you what your experiences have been while riding and doing your job in the M113A1. We are going to ask about many different things, like conditions inside, possible safety hazards, difficulty in using the equipment, and problems in doing your job. In answering this questionnaire please give

information only about your own personal experiences with the M113A1.

For each statement in the questionnaire please select one of the four answers listed below. Your answer will tell us how much of a problem that item has been throughout the test while you have been riding and doing your job in the M113A1. The answer choices are:

0 no problem
1 a minor problem
2 a moderate problem
3 a serious problem

In deciding your answer, please consider both how often and how much the item has been a problem for you. Please indicate your answer choice (0, 1, 2, or 3) in the space in front of the item.

Additionally, some statements may ask for a short response. Please write these comments on the lines provided.

Copies of the questionnaire for each duty position and data summaries follow.

MEAN RESPONSES OF TRACK COMMANDERS TO THE
GENERAL HUMAN FACTORS QUESTIONNAIRE

MICV	M113A1		
1.50	.50	1.	Objects sticking out in the vehicle that were safety hazards.
1.00	1.25	2.	Amount of padding on periscopes.
1.17	1.17	3.	Unsafe storage of any weapons.
1.08	1.25	4.	Unsafe conditions while any weapons were being fired.
1.08	.75	5.	Controls in the vehicle that could be activated accidentally and result in a safety hazard.
1.08	1.83	6.	The amount of safety crash padding inside the vehicle.
1.25	1.33	7.	Not enough air when the vehicle was buttoned up.
1.50	1.83	8.	Noise that caused you to have trouble hearing communications.
1.50	1.92	9.	Noise that was annoying to you.
.92	1.75	10.	Noise that caused hearing problems lasting after the noise stopped.
1.08	.83	11.	Lighting conditions inside the vehicle.
.58	.75	12.	Lighting conditions outside the vehicle.
1.00	1.58	13.	Something about the vehicle that made riding or being in it very fatiguing.
.83	1.33	14.	General discomfort while in the vehicle for only short time periods.
1.17	1.83	15.	General discomfort while in the vehicle for long time periods.
.33	1.17	16.	Discomfort while riding at slow speeds.
.58	1.75	17.	Discomfort while riding at high speeds.
1.92	1.33	18.	Crowding or cramped space while in the vehicle.
.67	.83	19.	High temperature inside the vehicle.
1.08	1.42	20.	Low temperature inside the vehicle.
.67	.50	21.	Any conditions that made you feel motion sick.
1.00	1.58	22.	Vibration in the vehicle.
1.42	.67	23.	Fumes from the vehicle or weapons.
1.17	1.25	24.	The amount of ventilation in the vehicle.
.92	2.25	25.	Being bounced around while the vehicle was under way.
1.45	1.55	26.	Difficulty, inconvenience, or discomfort using your seat belt.

MICV	M113A1		
1.17	.92	27.	Getting cramped so that it was hard to dismount or do your job after dismounting.
1.58	1.08	28.	Too little leg room.
1.08	1.08	29.	Too little head room.
1.17	1.08	30.	Loading plan of the vehicle.
1.08	1.00	31.	Ability to get your squad weapon when required.
1.42	1.25	32.	Adequacy and accessibility of safety/emergency equipment.
2.08	1.33	33.	Ability to care for injured persons in the vehicle.
.75	.83	34.	Headset/helmet design for comfort.
2.00	1.17	35.	Headset/helmet difficulties during dismount.
1.08	1.42	36.	Too few stations on the communication network inside the vehicle.
1.50	1.67	37.	Malfunctions of the radio/intercom system.
2.18	1.00	38.	Broken headsets.
.58	.67	39.	Ramp operation or obstructions.
1.25	1.33	40.	Difficulties with your seat.
.27	.45	41.	Malfunctions of your seat belt.
.75	.67	42.	Feeling motion sick when buttoned up.
.58	.92	43.	Feeling motion sick when riding for long periods at high speeds.
1.58	.83	44.	Difficulty entering the vehicle to get to your seat.
1.83	.83	45.	Difficulty getting out of the vehicle from your seat.
2.33	1.50	46.	Clothing and web gear snagging when entering or leaving vehicle.
1.91	.73	47.	The weapons rack getting in my way.
1.73	.55	48.	Sharp edges on the weapons rack.
2.00	1.27	49.	Difficulty getting over or by other squad members' seats.
1.83	1.17	50.	Difficulty seeing through periscopes because of mud, etc., covering them.
1.33	1.08	51.	Difficulty seeing because periscopes were fogged.
1.08	.75	52.	Difficulty seeing through periscopes because they vibrated.
1.25	.92	53.	Difficulty seeing through periscopes because of glare.
1.00	1.17	54.	Difficulty with loose items (e.g., expended cartridges) on the floor.

Track commander items

MICV	M113A1		
.92	.42	55.	Ability to see at night from your station (open hatch).
.83	.25	56.	Ability to see in daylight from your station (open hatch).
1.17	1.00	57.	Ability to see in bad weather (open hatch).
1.67	2.25	58.	Ability to see while "buttoned up" in daylight.
1.08	1.30	59.	Difficulty seeing through the periscopes because of the sun's glare.
2.17	2.42	60.	Ability to see while "buttoned up" at night.
.58	.58	61.	Difficulty with external lights of the vehicle.
2.08	2.25	62.	Ability to see in bad weather while "buttoned up".
2.27	.82	63.	Obstructions blocking the view from your hatch.
1.17	1.33	64.	The lack of a windshield.
1.42	.92	65.	Difficulties operating your hatch.
1.09	.73	66.	Track commander's seat too close to the back of the driver's seat.
1.36	.73	67.	Any difficulties with your seat while mounting or dismounting.
.91	.73	68.	Any other difficulties with your seat.
1.36	.45	69.	Difficulties operating your periscopes.
1.40	.50	70.	Periscopes that wouldn't stay up or got knocked down.
1.17	1.17	71.	Adequacy of the radio equipment.
1.33	1.50	72.	Adequacy of the intercom equipment.
1.18	1.18	73.	Ability to reach the intercom box when track commander's hatch is open.

Track commander items

MICV	M113A1		
.58	.92	74.	Ability to control the activities of the driver while you were in the vehicle.
1.83	1.58	75.	Ability to control the activities of the driver while you were dismounted.
1.83	.92	76.	Difficulties with detection and identification of targets from your station.
.82	.82	77.	Ability to determine where the main weapon was oriented relative to the front of the vehicle (using the LED panel).
.90	.90	78.	Ability to guide the main gunner to a target by using the LED panel.
1.55	1.36	79.	Weapons being fired near your hatch.
1.50	1.00	80.	Ability to control the firing activity of the main weapon(s).
1.70	1.20	81.	Ability to control the firing activity of the Firing Port Weapons.
2.17	1.83	82.	Ability to control the vehicle fire power while you were dismounted.
1.45	.91	83.	Difficulty with command of your squad because of delays in your ability to dismount the vehicle.
1.50	.92	84.	Difficulty with command of your squad because of how early you had to enter the vehicle during vehicle mount.
1.67	1.33	85.	Difficulty with communication during mount or dismount of the vehicle.
1.25	1.42	86.	Difficulty doing your job while on the move in the vehicle.
1.33	1.00	87.	Too little space in the track commander's station.
1.50	1.33	88.	Difficulty reaching needed stored items.
1.58	1.17	89.	Difficulty reaching your M16A1 in its stored position.
		90.	Are there any other problems with this vehicle that have made it difficult for you to perform your job as track commander (either at your duty station or elsewhere)? If yes, please write them briefly below.

MEAN RESPONSES OF DRIVERS TO THE
GENERAL HUMAN FACTORS QUESTIONNAIRE

MICV	M113A1		
1.21	.93	1.	Objects sticking out in the vehicle that were safety hazards.
1.00	1.36	2.	Amount of padding on periscopes.
.79	1.50	3.	Unsafe storage of any weapons.
.93	1.36	4.	Unsafe conditions while any weapons were being fired.
1.07	.57	5.	Controls in the vehicle that could be activated accidentally and result in a safety hazard.
1.64	1.93	6.	The amount of safety crash padding inside the vehicle.
.79	1.29	7.	Not enough air when the vehicle was buttoned up.
.86	1.64	8.	Noise that caused you to have trouble hearing communications.
.93	1.43	9.	Noise that was annoying to you.
.86	.93	10.	Noise that caused hearing problems lasting after the noise stopped.
.43	1.00	11.	Lighting conditions inside the vehicle.
.21	.21	12.	Lighting conditions outside the vehicle.
.71	1.36	13.	Something about the vehicle that made riding or being in it very fatiguing.
.43	1.14	14.	General discomfort while in the vehicle for only short time periods.
1.00	1.86	15.	General discomfort while in the vehicle for long time periods.
.64	.79	16.	Discomfort while riding at slow speeds.
.64	1.50	17.	Discomfort while riding at high speeds.
.93	.79	18.	Crowding or cramped space while in the vehicle.
.36	.86	19.	High temperature inside the vehicle.
1.14	1.57	20.	Low temperature inside the vehicle.
.29	.21	21.	Any conditions that made you feel motion sick.
.93	1.57	22.	Vibration in the vehicle.
.93	.86	23.	Fumes from the vehicle or weapons.
.50	1.36	24.	The amount of ventilation in the vehicle.
1.00	1.57	25.	Being bounced around while the vehicle was under way.
.58	.75	26.	Difficulty, inconvenience, or discomfort using your seat belt.

MICV	M113A1		
.93	.64	27.	Getting cramped so that it was hard to dismount or do your job after dismounting.
.57	.71	28.	Too little leg room.
.43	.36	29.	Too little head room.
.50	.57	30.	Loading plan of the vehicle.
.43	.29	31.	Ability to get your squad weapon when required.
.57	.79	32.	Adequacy and accessibility of safety/emergency equipment.
1.38	1.08	33.	Ability to care for injured persons in the vehicle.
.17	.64	34.	Headset/helmet design for comfort.
.36	.57	35.	Headset/helmet difficulties during dismount.
.29	.86	36.	Too few stations on the communication network inside the vehicle.
.93	1.21	37.	Malfunctions of the radio/intercom system.
1.36	1.29	38.	Broken headsets.
1.07	.64	39.	Ramp operation or obstructions.
.93	.57	40.	Difficulties with your seat.
.54	.54	41.	Malfunctions of your seat belt.
.21	.21	42.	Feeling motion sick when buttoned up.
.29	.21	43.	Feeling motion sick when riding for long periods at high speeds.
1.14	.64	44.	Difficulty entering the vehicle to get to your seat.
1.07	.57	45.	Difficulty getting out of the vehicle from your seat.
2.14	1.07	46.	Clothing and web gear snagging when entering or leaving vehicle.
1.08	.54	47.	The weapons rack getting in my way.
1.46	.38	48.	Sharp edges on the weapons rack.
1.57	1.00	49.	Difficulty getting over or by other squad members' seats.
2.07	1.00	50.	Difficulty seeing through periscopes because of mud, etc., covering them.
1.50	.86	51.	Difficulty seeing because periscopes were fogged.
1.07	.57	52.	Difficulty seeing through periscopes because they vibrated.
1.14	.86	53.	Difficulty seeing through periscopes because of glare.
1.43	.71	54.	Difficulty with loose items (e.g., expended cartridges) on the floor.

Driver items

MICV	M113A1		
.29	1.21	55.	Difficulty steering the vehicle.
.43	.29	56.	Difficulty with the operation of the accelerator.
.57	1.14	57.	Transmission shifting too slowly.
.50	.71	58.	Any other difficulty with operation of the transmission.
.43	1.21	59.	Difficulty with the operation of the brakes.
.64	1.07	60.	Difficulty with track replacement.
1.21	.43	61.	Difficulty reading any visual display.
.79	.64	62.	Difficulty operating any other controls.
1.36	.14	63.	Periscopes that wouldn't stay up or got knocked down.
.57	.43	64.	Adequacy of storage in the driving compartment.
.14	.00	65.	Vision in daylight when the hatch was open.
.29	.07	66.	Vision at night when the hatch was open.
.86	.93	67.	Vision through the periscopes in daylight when "buttoned up".
1.08	1.31	68.	Difficulty seeing through the periscopes because of the sun's glare.
1.00	1.57	69.	Vision through the periscopes at night when "buttoned up".
1.00	1.62	70.	Vision during bad weather when the hatch was open.
1.85	1.77	71.	Vision during bad weather when "buttoned up".
.21	.57	72.	Difficulty seeing with the blackout lights.
.00	.00	73.	Difficulty seeing with the headlights.
.57	.07	74.	Any other obstructions to vision.
1.58	.92	75.	Adequacy of mud flaps.
1.15	1.77	76.	The lack of a windshield.
.14	.07	77.	Getting gas in the "bilge" during refueling.
1.36	1.57	78.	Weapon(s) being fired near your hatch.
1.00	1.64	79.	Difficulty knowing where the main gunner's weapon(s) were pointed relative to the front of the vehicle.
.50	.79	80.	Difficulty coordinating with the gunner when the track commander was dismounted.
.50	.86	81.	Difficulty coordinating with the track commander.
.64	1.29	82.	Adequacy of the night vision equipment.
.86	.21	83.	Difficulties with the driver's hatch.
.50	.50	84.	Too little space in the driver's compartment.
.93	.64	85.	Fumes from weapon(s) firing.
1.43	2.00	86.	Noise from weapon(s) firing.
.93	1.07	87.	Difficulty reaching tools, grease gun, or personal items.
.43	1.14	88.	Difficulty reaching radio/intercom controls.
1.79	.93	89.	Difficulty seeing all instruments in some driving positions.

.79	.86	90.	Difficulty reaching things while working in the engine compartment.
.64	2.00	91.	Not enough power to climb hills fast.
.50	1.57	92.	Not enough power for use in mud.
		93.	Are there any other problems with this vehicle that have made it difficult to perform your job as driver (either at your duty station or elsewhere)? If yes, please write them briefly below.

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MEAN RESPONSES OF MAIN GUNNERS TO THE
GENERAL HUMAN FACTORS QUESTIONNAIRE

MICV	M113A1		
.75	1.17	1.	Objects sticking out in the vehicle that were safety hazards.
.67	1.25	2.	Amount of padding on periscopes.
.42	1.83	3.	Unsafe storage of any weapons.
.58	1.25	4.	Unsafe conditions while any weapons were being fired.
.83	.67	5.	Controls in the vehicle that could be activated accidentally and result in a safety hazard.
.75	2.08	6.	The amount of safety crash padding inside the vehicle.
.33	1.17	7.	Not enough air when the vehicle was buttoned up.
.92	1.50	8.	Noise that caused you to have trouble hearing communications.
.67	1.08	9.	Noise that was annoying to you.
.67	1.00	10.	Noise that caused hearing problems lasting after the noise stopped.
.08	.75	11.	Lighting conditions inside the vehicle.
.33	.75	12.	Lighting conditions outside the vehicle.
.50	1.50	13.	Something about the vehicle that made riding or being in it very fatiguing.
.33	.75	14.	General discomfort while in the vehicle for only short time periods.
.83	1.67	15.	General discomfort while in the vehicle for long time periods.
.25	1.08	16.	Discomfort while riding at slow speeds.
.67	1.58	17.	Discomfort while riding at high speeds.
.83	1.50	18.	Crowding or cramped space while in the vehicle.
.33	.67	19.	High temperature inside the vehicle.
1.50	2.33	20.	Low temperature inside the vehicle.
.08	.25	21.	Any conditions that made you feel motion sick.
.58	1.67	22.	Vibration in the vehicle.
.75	.92	23.	Fumes from the vehicle or weapons.
.50	1.25	24.	The amount of ventilation in the vehicle.
.92	2.50	25.	Being bounced around while the vehicle was under way.
.25	1.08	26.	Difficulty, inconvenience, or discomfort using your seat belt.
.50	.92	27.	Getting cramped so that it was hard to dismount or do your job after dismounting.
1.00	.92	28.	Too little leg room.
.33	.58	29.	Too little head room.
.67	1.25	30.	Loading plan of the vehicle.
1.25	.58	31.	Ability to get your squad weapon when required.

MICV	M113A1		
.50	1.00	32.	Adequacy and accessibility of safety/emergency equipment.
1.50	1.42	33.	Ability to care for injured persons in the vehicle.
.58	1.17	34.	Headset/helmet design for comfort.
.75	.67	35.	Headset/helmet difficulties during dismount.
.67	1.08	36.	Too few stations on the communication network inside the vehicle.
.50	1.00	37.	Malfunctions of the radio/intercom system.
1.50	1.00	38.	Broken headsets.
.25	.33	39.	Ramp operation or obstructions.
.67	.42	40.	Difficulties with your seat.
.08	.50	41.	Malfunctions of your seat belt.
.33	.50	42.	Feeling motion sick when buttoned up.
.25	.33	43.	Feeling motion sick when riding for long periods at high speeds.
.92	.58	44.	Difficulty entering the vehicle to get to your seat.
1.00	.75	45.	Difficulty getting out of the vehicle from your seat.
1.75	1.08	46.	Clothing and web gear snagging when entering or leaving vehicle.
.67	.55	47.	The weapons rack getting in my way.
.55	.36	48.	Sharp edges on the weapons rack.
1.50	1.25	49.	Difficulty getting over or by other squad members' seats.
1.33	1.50	50.	Difficulty seeing through periscopes because of mud, etc., covering them.
1.50	1.50	51.	Difficulty seeing because periscopes were fogged.
.58	1.50	52.	Difficulty seeing through periscopes because they vibrated.
1.00	1.08	53.	Difficulty seeing through periscopes because of glare.
.67	1.08	54.	Difficulty with loose items (e.g., expended cartridges) on the floor.

MICV main gunner items

MICV	M113A1		
.33	.33	55.	Ability to see at night (open hatch).
1.25	2.33	56.	Ability to see at night ("buttoned up").
.17	.58	57.	Difficulty with external lights of the vehicle.
.08	.00	58.	Ability to see in daylight (open hatch).
.58	.50	59.	Ability to see in daylight ("buttoned up").
.75	.83	60.	Ability to see in bad weather (open hatch).
1.17	1.92	61.	Ability to see in bad weather ("buttoned up").
.75	.75	62.	Difficulties with your hatch.
.50		63.	Difficulties with the jump seat.
.50		64.	Difficulties operating "buttoned up".
.58		65.	The lack of a windshield when operating open hatch.
.83		66.	The lack of hand-holds in the turret.
1.50		67.	Being thrown around in the turret.
1.42		68.	Too little space in the turret.
1.09	.18	69.	Confusion due to the number of tasks you need to do (e.g., checking switch positions) to get ready to engage a target. (M113 Q65, same)
.83	.33	70.	Confusion because of the number of decisions you had to make (e.g., which weapon to use) when getting ready to engage a target. (M113 Q66, same)
1.00	.75	71.	Difficulties getting target fire control information from the track commander or others. (M113 Q67, same)
.58	.67	72.	Difficulty coordinating with the driver when the track commander was dismounted. (M113 Q68, same)
.75		73.	Difficulty keeping track of where your turret was positioned relative to the front of the MICV.
1.17	.58	74.	The ability to remain oriented as to vehicle direction. (M113 Q69, same)
.83		75.	The ability to reorient and locate targets using the LED device.
1.58		76.	Sudden elevation of guns when passing over a hatch.
.58		77.	Difficulty learning how to move the gun controls to elevate or traverse the weapons.
.42	.75	78.	The ability to acquire targets. (M113 Q71, same)
1.92	1.42	79.	The ability to hold the weapon on the target while in the unstabilized mode. (M113 Q72, about the same)
.50		80.	The ability to hold the weapon on the target while in the stabilized mode.
.50	1.17	81.	The ability to track a fast moving target. (M113 Q73, same)
.08	.33	82.	The ability to track a slow moving target. (M113 Q74, same)

MICV	M113A1		
1.08	.92	83.	Difficulty seeing through the sights because of the sun's glare. (M113 Q78, same)
.75		84.	The ability to engage targets with the coaxial machine-gun while moving.
.50	1.58	85.	The ability to engage targets with the main gun while moving. (M113 Q75, about the same)
.92	1.75	86.	The ability to keep eyes near the gun sights when the vehicle is moving. (M113 Q77, ability to sight while on the move)
.58	1.83	87.	Noise level while firing. (M113 Q79, same)
1.92	2.50	88.	Too cold in turret. (M113 Q82, cold in the gunner's hatch)
.33		89.	Too hot in turret.
.58	.75	90.	Fumes from expended ammunition. (M113 Q81, same)
.58	1.25	91.	The system for getting rid of expended ammunition cartridges. (M113 Q80, expended ammunition cartridges on the floor of the vehicle)
1.58		92.	Amount of storage space in the turret.
1.25		93.	Difficulty loading the guns.
1.00		94.	Difficulty maintaining zero of both weapons.
1.33		95.	Difficulty with image quality of the night sighting equipment.
1.25		96.	Difficulty seeing targets at more than 200 meters using the night sighting equipment.
1.00		97.	Difficulty knowing whether guns were in "safety" position.
.08		98.	Difficulty with "cook-offs".
1.00		99.	Difficulty finding things in the turret in the dark.
2.00		100.	Difficulty reaching my M16A1 because of where it has to be stored.
.33		101.	Difficulty operating the turret shield.
1.17		102.	Difficulty correctly installing the feeder chutes.
1.33		103.	Difficulty correctly installing the dual feeder.
1.83		104.	20mm weapon dual feeder too heavy.
1.75		105.	Jamming of the dual feeder.

MICV	M113A1		
1.42		106.	Difficulty with round alignment.
1.17		107.	20mm weapon has too many parts.
1.08	1.33	108.	Mud being thrown on you, the sights, or the weapons when the vehicle is on the move. (M113 Q84, same)
		109.	Are there any other problems with this vehicle that have made it difficult to perform your job as main gunner (either in the turret or elsewhere)? If yes, please write them briefly below.

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M113A1 gunner items

M113A1		
.33	55.	Ability to see at night (open hatch).
2.33	56.	Ability to see at night ("buttoned up").
.58	57.	Difficulty with external lights of the vehicle.
.00	58.	Ability to see in daylight (open hatch).
.50	59.	Ability to see in daylight ("buttoned up").
.83	60.	Ability to see in bad weather (open hatch).
1.92	61.	Ability to see in bad weather ("buttoned up").
.75	62.	Difficulties with your hatch.
1.58	63.	Being thrown around in the gunner's compartment.
.83	64.	Difficulties keeping track of where the vehicle is when operating buttoned up.
.17	65.	Confusion due to the number of tasks you need to do to get ready to engage a target.
.33	66.	Confusion because of the number of decisions you had to make when getting ready to engage a target.
.75	67.	Difficulties getting target fire control information from the track commander or others.
.67	68.	Difficulty coordinating with the driver when the track commander was dismounted.
.58	69.	The ability to remain oriented as to vehicle direction.
1.42	70.	Difficulty turning the turret ring by hand.
.75	71.	The ability to acquire targets.
1.42	72.	The ability to hold the weapon on the target.
1.17	73.	The ability to track a fast moving target.
.33	74.	The ability to track a slow moving target.
1.58	75.	The ability to engage targets while moving.
1.75	76.	The ability to hold the 50 calibre weapon in rough terrain.
1.75	77.	Ability to sight while on the move.
.92	78.	Difficulty seeing through the sights because of the sun's glare.
1.83	79.	Noise level while firing.
1.25	80.	Expended ammunition cartridges on the floor of the vehicle.
.75	81.	Fumes from expended ammunition.
2.50	82.	Cold in the gunner's hatch.
1.75	83.	Lack of padding for safety or comfort.
1.33	84.	Mud being thrown on you, the sights, or the weapon when the vehicle is on the move.

M113A1

85. Are there any other problems with this vehicle that have made it difficult to perform your job as main gunner (either at your duty station or elsewhere)? If yes, please write them briefly below.

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MEAN RESPONSES OF FPW GUNNERS TO THE
GENERAL HUMAN FACTORS QUESTIONNAIRE

MICV	M113A1		
1.25	.89	1.	Objects sticking out in the vehicle that were safety hazards.
76	1.07	2.	Amount of padding on periscopes.
.68	1.50	3.	Unsafe storage of any weapons.
.73	1.18	4.	Unsafe conditions while any weapons were being fired.
.61	.73	5.	Controls in the vehicle that could be activated accidentally and result in a safety hazard.
1.25	1.95	6.	The amount of safety crash padding inside the vehicle.
.68	1.14	7.	Not enough air when the vehicle was buttoned up.
.95	1.73	8.	Noise that caused you to have trouble hearing communications.
1.27	1.93	9.	Noise that was annoying to you.
1.02	1.75	10.	Noise that caused hearing problems lasting after the noise stopped.
.84	1.07	11.	Lighting conditions inside the vehicle.
.58	.84	12.	Lighting conditions outside the vehicle.
1.02	1.52	13.	Something about the vehicle that made riding or being in it very fatiguing.
.61	1.27	14.	General discomfort while in the vehicle for only short time periods.
1.18	1.73	15.	General discomfort while in the vehicle for long time periods.
.59	.95	16.	Discomfort while riding at slow speeds.
.75	1.86	17.	Discomfort while riding at high speeds.
1.66	1.66	18.	Crowding or cramped space while in the vehicle.
1.09	1.23	19.	High temperature inside the vehicle.
.70	1.59	20.	Low temperature inside the vehicle.
.80	.91	21.	Any conditions that made you feel motion sick.
1.14	2.00	22.	Vibration in the vehicle.
1.27	1.20	23.	Fumes from the vehicle or weapons.
.77	.95	24.	The amount of ventilation in the vehicle.
.84	1.89	25.	Being bounced around while the vehicle was under way.
.88	1.00	26.	Difficulty, inconvenience, or discomfort using your seat belt.
1.34	1.18	27.	Getting cramped so that it was hard to dismount or do your job after dismounting.
1.77	1.39	28.	Too little leg room.
1.07	1.02	29.	Too little head room.
.74	1.33	30.	Loading plan of the vehicle.
.64	.91	31.	Ability to get your squad weapon when required.

MICV	M113A1		
.65	.95	32.	Adequacy and accessibility of safety/emergency equipment.
1.53	1.35	33.	Ability to care for injured persons in the vehicle.
.83	.69	34.	Headset/helmet design for comfort.
.88	.74	35.	Headset/helmet difficulties during dismount.
.67	.91	36.	Too few stations on the communication network inside the vehicle.
1.14	1.23	37.	Malfunctions of the radio/intercom system.
1.63	1.26	38.	Broken headsets.
.55	.70	39.	Ramp operation or obstructions.
1.14	1.00	40.	Difficulties with your seat.
.36	.71	41.	Malfunctions of your seat belt.
.68	1.09	42.	Feeling motion sick when buttoned up.
.82	1.11	43.	Feeling motion sick when riding for long periods at high speeds.
1.18	.89	44.	Difficulty entering the vehicle to get to your seat.
1.25	1.11	45.	Difficulty getting out of the vehicle from your seat.
1.48	1.30	46.	Clothing and web gear snagging when entering or leaving vehicle.
1.46	.90	47.	The weapons rack getting in my way.
1.24	.44	48.	Sharp edges on the weapons rack.
1.57	1.00	49.	Difficulty getting over or by other squad members' seats.
1.50	.95	50.	Difficulty seeing through periscopes because of mud, etc., covering them.
1.07	.93	51.	Difficulty seeing because periscopes were fogged.
.60	.62	52.	Difficulty seeing through periscopes because they vibrated.
.67	.71	53.	Difficulty seeing through periscopes because of glare.
.64	1.09	54.	Difficulty with loose items (e.g., expended cartridges) on the floor.

Firing port weapon gunner items

FPW MICV	OTHER M113A1		
1.25		55.	Ability to see at night from your station.
.77		56.	Ability to see in daylight from your station.
1.34		57.	Ability to see from your station in bad weather (e.g., rain).
.89		58.	Difficulty seeing from your station because of the sun's glare.
1.18		59.	Ability to keep oriented as to where the vehicle is by looking through your periscope.
1.55		60.	Lack of ability to adjust the height of my seat.
.48		61.	Firing port weapons in the way while riding in the MICV.
.75		62.	Adequacy of the radio and intercom equipment.
1.11		63.	Ability to coordinate with your Squad Leader while in the vehicle.
.89	1.39	64.	Ability to hear commands. (M113 Q58, same)
1.23	1.07	65.	Ability to see hand signals. (M113 Q59, ability to see squad leader or fire team leader signals from your seat in the vehicle)
.98	1.36	66.	Confusion about where you were because of limited ability to see outside while "buttoned up". (M113 Q56, not knowing where to go upon dismounting because of not knowing where you were.)
.84		67.	Difficulty placing your weapon in the firing port.
.80		68.	Difficulty with the system holding your weapon in the firing port.
.68		69.	Difficulty removing your firing port weapon.
.82		70.	The ability to acquire targets with the firing port weapon.
.61		71.	The ability to hold your firing port weapon on the target until it was hit.
.52		72.	The ability to hit targets with the firing port weapon.
.86		73.	Being able to aim your firing port weapon accurately.
1.48		74.	Ability to aim your firing port weapon without the use of tracers.
.98		75.	Difficulty reaching more ammunition or locating the correct ammunition box.
1.34		76.	No place to put extra ammunition magazines.
.68		77.	Difficulty loading your weapon.
.80		78.	Difficulty changing magazines.
.82		79.	The amount of ammunition you had to use to hit a target.

FPW MICV	OTHER M113A1		
1.07	1.36	80.	Noise in the vehicle during live firing. (M113 Q61, noise from weapon(s) firing)
.98		81.	Difficulty clearing stoppages of your firing port weapon.
.80		82.	The capacity of system for gathering expended cartridges.
.64		83.	Ability to check the position of the safety on your firing port weapon.
1.07	.81	84.	Fumes in the vehicle while firing. (M113 Q60, fumes from weapon(s) firing)
1.25		85.	Room to move around as needed during the firing of your weapon.
1.34		86.	Your ability to swivel your weapon to cover your entire viewing angle.
.77		87.	Bumping into the man next to you while trying to swivel your weapon.
.95		88.	Your ability to steady yourself so that you could fire your weapon accurately.
1.02		89.	Difficulty avoiding shooting too low.
1.16		90.	Difficulty avoiding shooting too high.
1.00		91.	Your ability to fire your weapon while the vehicle was moving.
1.23		92.	Mud getting on your periscope.
.57		93.	Mud stopping up your firing port weapon.
1.14		94.	Ability to use seat belt while firing the firing port weapon.
.89		95.	Adequacy of storage space for your personal M16A1.
.60		96.	Adequacy of storage space for your firing port weapon.
		97.	Are there any other problems with this vehicle that have made it difficult to perform your job as firing port weapon gunner (either at your duty station or elsewhere)? If yes, please write them briefly below.

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Other squad member items

M113A1		
1.48	55.	Not knowing where you were because no periscope was available to you.
1.36	56.	Not knowing where to go upon dismounting because of not knowing where you were.
1.61	57.	Not knowing the situation because of noise and not having a headset.
1.34	58.	Ability to hear commands.
1.07	59.	Ability to see squad leader or fire team leader signals from your seat in the vehicle.
.82	60.	Fumes from weapon(s) firing.
1.39	61.	Noise from weapon(s) firing.
	62.	Are there any other problems with this vehicle that have made it difficult to perform your job? If yes, please write them briefly below.

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2. QUALITY OF COMPARATIVE DESIGN, INCLOSURE 2

MEAN RESPONSES OF ALL TEST SUBJECTS ON THE
"QUALITY OF COMPARATIVE DESIGN" QUESTIONNAIRE

Next we want you to compare the MICV and the M113A1 on the following list of things that would probably be good features for squad mechanized vehicles to have. For each feature on the list, rate <u>how good</u> you think the design is by using the following answers:

0 = Not Good

1 = Somewhat Good

2 = Good

3 = Very Good

Please use the two columns at the right of each feature to record the number of your ratings (from 0 to 3). Please be sure to rate <u>both</u> vehicles on every item.

		MICV	p	M113A1
1.	Power of the engine	2.69	.001	1.29
2.	Speed of the vehicle.	2.80	.001	1.16
3.	The transmission.	2.05	-	1.82
4.	Maneuverability.	2.55	.001	1.69
5.	Protection of the vehicle armor.	2.14	.001	1.14
6.	Fire power of the main weapon(s).	2.58	.001	1.40
7.	Protection for the main gunner.	2.30	.001	0.48
8.	Ability to fire main weapon(s) accurately on the move.	2.29	.001	0.88
9.	The vehicle suspension system.	2.48	.001	1.06
10.	The ability of the squad to fight from inside.	2.22	.001	0.51
11.	The ability to see out while buttoned up.	1.92	.001	0.64
12.	The personnel heater.	2.27	.001	0.73
13.	Ventilation in the vehicle while while buttoned up.	2.29	.001	0.84
14.	Ability to camouflage vehicle shape.	2.10	.025	1.86

		MICV	p	M113A1
15.	Ability to camouflage vehicle shape.	2.10	.025	1.86
16.	Ease of vehicle maintenance.	1.79	-	1.84
17.	Ease of weapons maintenance.	1.55	.001	2.01
18.	Reliability of vehicle.	1.94	.001	1.46
19.	Reliability of weapons system.	1.67	-	1.76
20.	Comfort of ride.	2.37	.001	.72
21.	Space available for the squad.	1.21	-	1.43
22.	Storage space inside the vehicle.	1.36	-	1.27
23.	Storage space outside the vehicle.	2.29	.001	1.30
24.	Survivability of the vehicle.	1.96	.001	1.29
25.	Ease of exiting or entering under fire.	1.62	-	1.80
26.	Field of view for Track Commander.	1.56	.025	1.94
27.	Field of view for Driver.	2.14	-	2.18
28.	Field of view for Main Gunner.	2.61	-	2.41
29.	Field of view of Other Squad Members	1.88	.001	0.80
30.	Ability to keep up with main battle tanks.	2.65	.001	0.71
31.	Ability to go where main battle tanks can go.	2.54	.001	1.11
32.	Ability to swim the vehicle.	0.51	.001	1.56
33.	Ability of the vehicle to climb fast.	2.31	.001	1.02
34.	The intercom system.	2.12	.001	1.09
35.	The night sights.	2.24	.001	1.04
36.	The night viewing equipment.	2.22	.001	1.31
37.	The periscopes.	2.00	.001	1.45
38.	The driving and/or blackout lights.	2.12	.001	1.71
39.	Ability to move at night quietly.	1.75	.001	1.13
40.	Performance of vehicle in mud.	1.87	-	1.74
41.	Performance of vehicle in sand.	1.67	-	1.52
42.	Performance of vehicle in rocky terrain.	1.84	.001	1.42
43.	Performance of vehicle in heavy train.	2.12	.001	1.67

	MICV	p	M113A1
44. Ability to get at needed thgs in in vehicle.	1.60	-	1.66
45. Overall design giving confidence in vehicle.	2.07	.001	1.17

MEAN RESPONSES OF TRACK COMMANDERS ONLY ON THE
"QUALITY OF COMPARATIVE DESIGN" QUESTIONNAIRE

Next we want you to compare the MICV and the M113A1 on the following list of things that would probably be good features for squad mechanized vehicles to have. For each feature on the list, rate how good you think the design is by using the following answers:

0 = Not Good

1 = Somewhat Good

2 = Good

3 = Very Good

Please use the two columns at the right of each feature to record the number of your ratings (from 0 to 3). Please be sure to rate both vehicles on every item.

		MICV	p	M113A1
1.	Power of the engine	2.92	.01	1.25
2.	Speed of the vehicle.	2.92	.01	1.17
3.	The transmission.	1.83	-	2.17
4.	Maneuverability.	2.67	.01	1.50
5.	Protection of the vehicle armor.	1.92	.05	1.00
6.	Fire power of the main weapon(s).	2.75	.01	0.92
7.	Protection for the main gunner.	2.25	.01	0.33
8.	Ability to fire main weapon(s) accurately on the move.	2.25	.01	0.83
9.	The vehicle suspension system.	2.58	.01	0.92
10.	The ability of the squad to fight from inside.	1.92	.01	0.25
11.	The ability to see out while buttoned up.	1.50	.01	0.00
12.	The personnel heater.	2.17	.01	0.58
13.	Ventilation in the vehicle while while buttoned up.	2.00	.01	0.75
14.	Ability to camouflage vehicle shape.	2.25	-	2.17

		MICV	p	M113A1
15.	Ease of vehicle maintenance.	1.50	-	2.00
16.	Ease of weapons maintenance.	0.92	.01	2.42
17.	Reliability of vehicle.	1.92	-	2.00
18.	Reliability of weapons system.	1.42	.02	2.33
19.	Comfort of ride.	2.67	.01	0.83
20.	Space available for the squad.	0.92	.01	1.75
21.	Storage space inside the vehicle.	1.08	-	1.42
22.	Storage space outside the vehicle.	1.92	-	1.58
23.	Survivability of the vehicle.	1.75	-	1.33
24.	Ease of exiting or entering under fire.	1.27	-	2.00
25.	Field of view of Track Commander.	0.92	.05	1.92
26.	Field of view for Driver.	1.75	-	2.25
27.	Field of view for Main Gunner.	2.42	-	2.42
28.	Field of view for Other Squad Members.	1.75	-	1.58
29.	Ability to keep up with main battle tanks.	2.92	.01	0.58
30.	Ability to go where main battle tanks can go.	2.75	.01	1.17
31.	Ability to swim the vehicle.	0.00	.01	1.78
32.	Ability of the vehicle to climb fast.	2.42	.01	1.25
33.	The intercom system.	2.00	-	1.33
34.	The night sights.	2.50	.01	1.33
35.	The night viewing equipment.	2.42	.01	1.33
36.	The periscopes.	1.83	-	1.67
37.	The driving and/or blackout lights.	2.17	-	2.08
38.	Ability to move at night quietly.	2.17	.01	1.25
39.	Performance of vehicle in mud.	1.50	-	1.67
40.	Performance of vehicle in sand.	1.50	-	1.75
41.	Performance of vehicle in rocky terrain.	1.40	-	1.20
42.	Performance of vehicle in heavy rain.	2.08	-	1.92
43.	Ability to get at needed things in vehicle.	1.08	.01	1.75
44.	Overall design giving confidence in vehicle.	2.08	-	1.50

3. THINGS POSSIBLY NEEDING REDESIGN, INCLOSURE 3

MEAN RESPONSES OF TEST SUBJECTS ON THE
"THINGS POSSIBLY NEEDING REDESIGN" QUESTIONNAIRE

Some of the following parts or features of the MICV might be improved by additional redesign efforts before the vehicle goes into final production. We need your help in finding out what the need may be. For each item on the list below please rate the need for redesign based upon your experiences with the MICV throughout all field exercises and live fire. Use the following scores to show your ratings:

0 = No Redesign Needed

1 = Redesign Desirable (but might manage without it)

2 = Redesign Absolutely Necessary (danger or serious problem if not modified)

Please carefully consider each item and record your rating on the line in front.

TC	MAIN GUNNER	DRIVER	FPW GUNNER		
1.00*	.42	1.00	.64	1.	Mud flaps.
1.00	.08	.57	.44	2.	Track tension.
1.08	.33	.36	.44	3.	General track design.
1.25	.50	1.29	.61	4.	Periscopes.
.91	.42	1.07	.33	5.	Ability of periscopes to stay up.
1.08	.50	.57	.80	6.	Intercom system.
.67	.33	.36	.38	7.	Radio system.
1.25	.50	.36	.82	8.	Your seat.
1.67	.33	.71	.82	9.	Someone else's seat that is a problem for you.
.50	.00	.21	.40	10.	Seat belts.
1.08	.67	1.29	1.07	11.	Weapons rack.
.25	.08	.36	.24	12.	Ramp.
.75	.50	.93	.29	13.	Hatches.
.92	.83	1.00	.49	14.	Personnel heater.
.58	.17	.29	.39	15.	Ventilation.
1.00	.36	.29	.62	16.	Firing Port Weapon ports.
.58	.36	.29	.42	17.	Firing Port Weapons.
.33	1.00	.38	.24	18.	Coax machine gun.

TC	MAIN GUNNER	DRIVER	FPW GUNNER		
1.08	1.00	.46	.43	19.	20mm cannon.
1.18	1.00	.83	.86	20.	Dual feed system.
.33	.25	.15	.32	21.	Control to raise and lower cannon or move turret left and right.
.50	.92	.38	.49	22.	Night sight.
.75	.50	.38	.69	23.	Ability to operate main weapons over hatches.
1.00	.50	.31	.48	24.	Turret position locator (LED device).
.83	.67	.33	.46	25.	Other features of the turret.
.17	.09	.50	.21	26.	Driver's controls.
.92	.58	.86	.77	27.	Transmission(s).
.58	.33	.79	.33	28.	Brakes.
.67	.08	.71	.19	29.	Access to engine compartment.
.92	.33	.64	.73	30.	Storage/loading plan.
1.00	.33	.64	.84	31.	Weapons storage.
.75	.50	.64	.67	32.	System for gathering expended cartridges.
1.33	.75	1.07	1.00	33.	Pieces of metal (boxes, etc) that stick out and are hazards.
1.58	1.25	1.31	1.20	34.	Ability to aid an injured main gunner.
1.33	.67	.79	.91	35.	Ability to use the vehicle to handle injured persons.
.58	.50	.93	.78	36.	Safety padding.
1.08	1.17	1.57	.96	37.	Places where rain leaks occur.
1.58	1.08	1.29	1.33	38.	Space in vehicle to accommodate large men.
.25	.17	.21	.31	39.	Ability of the vehicle to be operated by small men.
.33	.00	.21	.33	40.	System for refueling.
				41.	Please list any other areas that need redesign on the lines below. Rate each one in the same way you have rated the above items.

_____

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*Note that some of the crew positions should be presumed to be less competent to rate some of these items (e.g., FPW gunner rating "Driver's controls".

SUGGESTIONS TO CORRECT DESIGN PROBLEMS

On the two previous pages you were asked to rate the need for redesign of several features of the MICV. For each of the features you rated a 2, Redesign Absolutely Necessary, please:

1. Write the number of the item on the list,

2. Write what the problem is, and

3. Briefly give us your ideas about what the designer could do to improve the situation.

If you need more paper to write your comments, please use the backs of this and prior pages.

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